# THE ORIGIN OF PHYSICAL LAWS

Ding-Yu Chung

In the vacuum universe model, the origin of physical laws comes from the cosmic evolution of vacuum in four stages: the pre-universe vacuum, the void space, the adjacent vacuum, and the empty space. The pre-universe is a vacuum with the vacuum energy slightly below the Planck energy. The vacuum fluctuation of the pre-universe vacuum results in pairs of supermembrane and anti-supermembrane and the void space. The supermembrane pairs and the void space are self-arranged into the semi-stable pre-expanding universe consisting of the positive energy boundary 9-branes and the negative energy boundary 9-brane separated by the bulk space with the positive energy pre-gravity and the negative energy pre-gravity. The collapse and the bounce of the pre-expanding universe result in the mixed pre-expanding universe consisting of two boundary mixed 9-branes with the absorbed void space. When the absorbed void space is emitted, it becomes the adjacent vacuum as the added space, which brings about the expansion with zero vacuum energy. The rupture of space by the superluminal inflation brings about the empty space as the gap among particles. The emergence of the empty space brings about the big bang, cosmic radiation, observable elementary particles, all force fields, and quantum mechanics. The periodic table of elementary particles is constructed to account for all elementary particles and their masses in a good agreement with the observed values. The cosmic evolution of vacuum involves a cyclic universe: the pre-universe, the pre-expanding universe, the mixed pre-expanding universe, the expansion, quintessence, the contraction, and back to the mixed pre-expanding universe.

## *1. Introduction*

Before the universe, the pre-universe is a vacuum with the vacuum energy slightly below the Planck energy. The vacuum fluctuation [1] of the pre-universe vacuum generates pairs of eleven dimensional supermembrane and anti-supermembrane: the positive energy ten dimensional superstring with the positive energy pre-gravity and the negative energy superstring with negative energy pre-gravity. The energy of the supermembrane is equal to the Planck energy. During the vacuum fluctuation, the concentration of energy to form the supermembrane pairs generates the void space without the capability for the vacuum fluctuation.

In the pre-universe, the force between the opposite superstrings (as opposite charges) is attractive, while the force between the opposite pre-gravities is repulsive. Consequently, the supermembrane pairs and the void space are self-arranged into the semi-stable pre-expanding universe, where the positive energy boundary 9-brane (superstring) and the negative energy boundary 9-brane are separated by the bulk space with the positive energy pre-gravity and the negative energy pre-gravity. The pre-expanding universe has the same structure as the

Horava-Witten model based on an eleven dimensional supergravity on a manifold with two ten-dimensional boundaries [2].

The pre-universe vacuum outside of the pre-expanding universe fills the void space in the bulk space, and the vacuum fluctuation continues. The continuous vacuum fluctuation in the bulk space increases the mass of the pre-expanding universe, and keeps the two boundary branes apart. It is analogous to that the fusion of hydrogen gas in a star increases the mass of the heavy core inside, and keeps the star from collapse.

The like-pre-gravity stays together, and forms one connective pre-gravity complex, the collective entanglement of the pre-gravity. The like-superstrings do not stay together, so there is no superstring complex.

At the critical mass of the pre-expanding universe when the rate of the vacuum fluctuation is too slow to keep the opposite boundary 9-branes apart, the pre-expanding universe collapses. The collapse coalesces the two boundary 9-branes and the void space into the mixed (neutral) 9-branes with the absorbed void space. The collapse does not result in annihilation, because due to quantum fluctuation, the large positive energy pre-gravity complex cannot match exactly with the large negative energy pre-gravity complex for the annihilation. The pre-gravity complexes remain intact. The intact pre-gravity complexes cause a bounce after the collapse. This bounced pre-expanding universe is the mixed pre-expanding universe, consisting of the boundary mixed 9-branes with the positive energy pre-gravity and the boundary mixed 9-branes with the negative energy pre-gravity. Both of the mixed 9-branes have the absorbed void space. The mixed pre-expanding universe is symmetrical to the pre-expanding universe as in Fig. 1. This inter-universal symmetry later becomes the pattern for the symmetry between the electric and the magnetic fields.

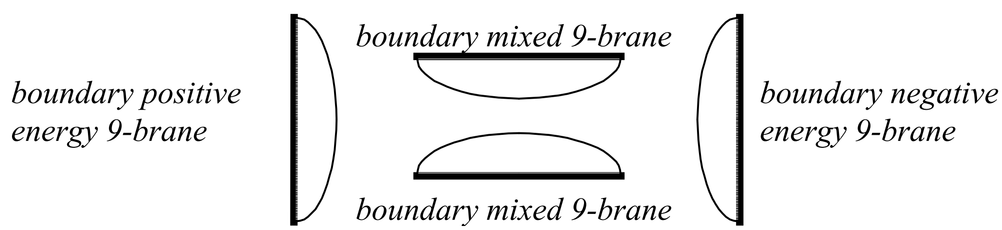



**Fig. 1:** the inter-universal symmetry between the pre- expanding universe with the boundary 9-branes and the mixed pre-expanding universe with the boundary mixed 9-branes

The interaction between branes in the form of collision is proposed in the ekpyrotic universe and other brane models [3,4]. The cyclic ekpyrotic universe model [5] has the collapse-singularity-bounce scheme.

As soon as the formation of the mixed pre-expanding universe is completed, the boundary mixed 9-branes emit the absorbed void space. The emitted void space becomes the added space to bring about the expansion with zero vacuum energy. The added space is the adjacent vacuum. The mixed pre-expanding universe is the beginning of the present cyclic universe with its own physical laws independent of the pre-universe.

In terms of elementary particles, the adjacent vacuum as the added space for the expansion is used to dilute (fractionalize) the high mass mixed 9-brane, because the adjacent vacuum is a part of the mixed brane. In the dilution process, the vacuum energy is zero. The diluted products are the hierarchical mixed branes from 9 to 3 whose masses decrease with the space-time dimension numbers as in the dimensional hierarchy [6], which is discussed in Section 2. The two different types (the big band and the big bang) of the expansion are described in Section3. The derivation of quantum mechanics is described in Section 4. The ordinary universe consists of the mixed 3-brane as the mixture of leptons and quarks. In Section 5, the periodic table of elementary particles is constructed to account of all leptons, quarks, gauge bosons, hadrons. In Section 6, the cyclic universe is proposed.

## *2. Dimensional hierarchy*

In terms of elementary particles, the added space (the adjacent vacuum) for the expansion is used to dilute (fractionalize) the high mass mixed 9-branes. The diluted products are the hierarchical mixed branes from 9 to 3 whose masses decrease with the space-time dimension numbers as in the dimensional hierarchy [6]. The lower space-time dimensions have the Kaluza-Klein structure

In the dimensional hierarchy with the Kaluza-Klein structure, the masses of space dimensions follow the hierarchical dimensional mass formula based on the Planck mass and the space-time dimension numbers as follows.

$$M_D = M_P\, \alpha^{2\,(11 - D)} \tag{1}$$

where $M_D$ is mass of a dimension, D is space-time dimension number, $M_P$ is the Planck mass (the mass of the supermembrane), and $\alpha$ is fine structure constant, the probability of a fermion emitting or absorbing a boson. The mass of the eleventh dimension is the Planck mass.

The hierarchical dimensional mass formula is derived from the assumption that each space dimension is occupied by a dimensional fermion $F_D$ and a dimensional boson $B_D$. The probability to transforming a fermion into its boson in the adjacent dimension is same as the fine structure constant, $\alpha$, the probability of a fermion emitting or absorbing a boson. The probability to transforming a boson into its fermion partner in the same dimension is also the fine structure constant, $\alpha$. This hierarchy is expressed in term of the dimension space-time number, D,

$$M_{D-1,\, B} = M_{D,\, F}\, \alpha_{D,\, F}, \tag{2}$$

$$M_{D,\, F} = M_{D,\, B}\, \alpha_{D,\, B}, \tag{3}$$

where $M_{D,B}$ and $M_{D,F}$ are the masses for a dimensional boson and a dimensional fermion, respectively, and $\alpha_{D,B}$ or $\alpha_{D,F}$ is the fine structure constant, which is the ratio between the energies of a dimensional boson and its dimensional fermionic partner. Assuming $\alpha$ is the same for all dimensional fermions and dimensional bosons, Eq. (1) is derived. (As shown later, with one exception, all $\alpha$'s are equal to $\alpha_e$, the fine structure constant for the electromagnetic field, so Eq. (1) is only approximately correct.)

## *3. The expansion: the big band and the big bang*

During the expansion, the added space for the expansion is used to dilute (franctionalize) the high mass boundary mixed 9-branes into the low mass hierarchical mixed branes. In the dilution process, the vacuum energy is zero. This vacuum dilution process has two different modes: the big band mode for the hidden universe and the big bang mode for the observable universe as Fig. 2 and Fig.3.

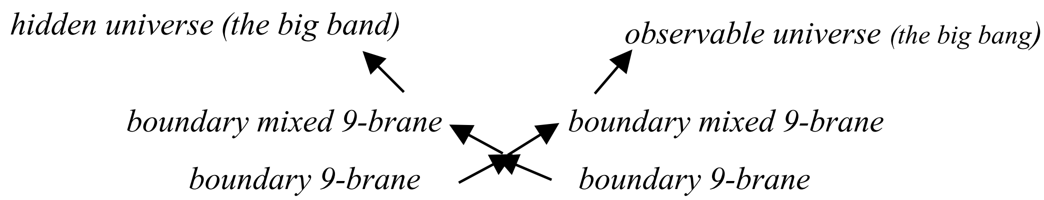



**Fig. 2:** the historical diagram for the formation of the observable and the hidden universes

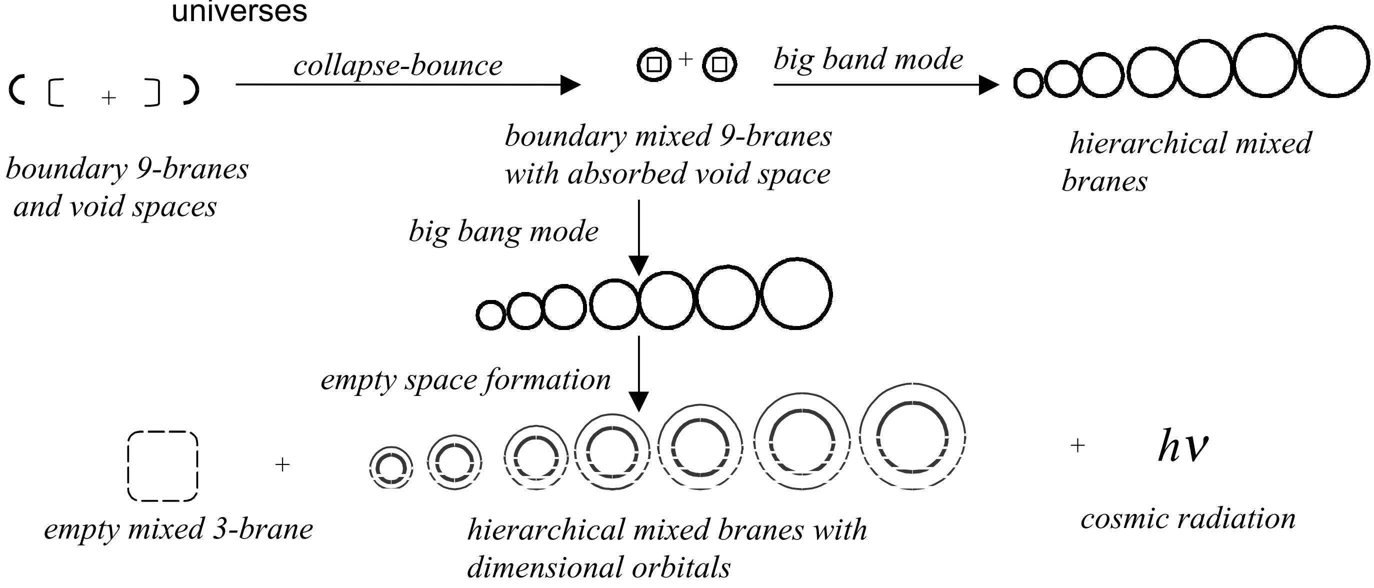



**Fig. 3:** the collapse-bounce and the vacuum dilution process (the big band mode and the big bang mode)

The big band mode is used in the hidden universe. In the big band mode, the mixed 9-brane is converted into the hierarchical mixed branes from 3 to 9, whose masses follow the hierarchical dimensional mass formula as Eq. (1) where p-brane has p + 1 space-time dimension, D. All mixed branes are adjacent to one another, and are held together by the pre-gravity complex. The 9-mixed branes is fractionalized into lower mixed branes slowly and sequentially without rupturing the connective pre-gravity complex. The conversion is in the extremely slow sequential stepwise fractionalization and condensation from the mixed 9-brane to the mixed 3-brane and back to the mixed 9-brane, resulting in expansion and contraction, like a big elastic rubber band (big band).

The big bang mode is used in the observable universe. The 9-mixed branes is fractionalized into all different mixed branes quickly in the superluminal inflation that ruptures the connective pre-gravity complex. The pre-gravity becomes individualized. The result is the formation of the empty space as the gap among the mixed branes. The mechanism to generate the empty space is to assign quantized positive and negative charges to the two internal boundary branes within the mixed brane, resulting in the dislocation of energy by the internal annihilation (implosion). The dislocation of energy from the mixed brane forms the empty space as the empty mixed 3-brane. (The movement of a massless particle leaves the empty space behind.) The dislocated energy is cosmic radiation. The attached pre-gravity also changes from the massive form to the massless form.

The mixed branes that are not annihilated have asymmetrical charges (CP nonconservation), in such way that the mixed brane has two asymmetrical sets (main and auxiliary) of space dimensions from the two boundary branes within the mixed brane. The auxiliary set is dependent on the main set, so the mixed brane appears to have only one set of space dimensions.

The empty space in the big bang mode allows all the mixed branes to have the same number of space dimensions. It is achieved by adding the virtual hierarchical space dimensions to the empty space surrounding the core mixed branes in the manner of the Kaluza-Klein structure, where the virtual space dimension is a one-dimensional circle associated with every point in the core brane dimension, and every higher virtual dimension circles the circle of the lower virtual dimension. The virtual space dimensions are the space dimensions in between the core brane space dimension and the gravity (the eleventh space-time dimension). The masses of the hierarchical space dimensions follow the hierarchical dimensional mass formula as Eq. (1).

To provide the virtual hierarchical space dimensions with the same space-time dimension as the core mixed brane, the core mixed brane absorbs the virtual hierarchical dimensions as the scalar fields through Higgs mechanism. (There is no free Higgs boson. So far no free Higgs boson has been detected.) The surrounding virtual hierarchical dimensions are converted into the "dimensional orbitals" with the same space-time dimension as the core mixed brane.

Gravity resided in the empty space is also a part of the hierarchical dimensional orbitals for the mixed branes. These hierarchical dimensional orbitals are the force and mass fields for the mixed branes in the big bang mode. The final forms of the mixed branes are the mixed branes from 3 to 9 surrounded by the hierarchical dimensional orbitals as the force and mass fields as Fig. 3.

Since the core mixed branes have two sets (main and auxiliary) of space dimensions, there are also two sets of the dimensional orbitals. For the mixed 3-brane in the big bang mode, there are two sets of the hierarchical seven dimensional orbitals (including gravity) and the non-hierarchical three core brane space dimensions. The mixed 3-brane is the mixture of leptons and quarks.

The empty space and cosmic radiation emerge only after the superluminal inflationary emergence of all of the hierarchical mixed branes. Consequently, the superluminal inflationary emergence of the mixed branes followed by the non-inflationary emergence of cosmic radiation constitutes the hybrid inflation [7]. Cosmic radiation, observable elementary particles, and all force fields emerge only at the end of inflation.

The two universes are parallel to each other. Without the empty space, the pre-gravity of the hidden universe is not developed as a long-range force field, so the hidden universe is hidden until the quintessence period.

## *4. Quantum mechanics*

The absorbed void space is emitted to become the added space for the expansion. This added space is the adjacent vacuum. The empty space is the generated as the gap among branes at the end of the inflation after the emergence of the adjacent vacuum. The empty space emerges after the adjacent vacuum, so to the adjacent vacuum, the space distance of the empty space does not exist.

Quantum mechanics is interpreted by the absorption and the emission of the adjacent vacuum. When matter absorbs the adjacent vacuum, there is no adjacent space for matter to expand. Consequently, matter is in the form of particle. To the adjacent vacuum, the space distance of the empty space does not exist, so when the adjacent vacuum is emitted, it can be anywhere in the gap among particles. Consequently, the matter that expands into the adjacent vacuum has the probability to be anywhere instantly in the form of wavefunction.

Each wavefunction is specific to a particular adjacent vacuum, so the entanglement (encounter) of different matters leads to the instant collapse of this wavefunction and the instant adsorption of the adjacent vacuum. It forms an entangled matter with the entangled adsorbed vacuum, which can then be emitted to bring about a new wavefunction.

## *5. The Ordinary Universe: the Periodic Table of Elementary Particles*

The observable universe consists of the mixed branes from 3 to 9. The ordinary (baryonic) universe in the observable universe consists of the mixed 3-

brane, which is the mixture of leptons and quarks. Exotic dark matter in the observable universe consists of the mixed branes from 4 to 9. As shown later, exotic dark matter cannot be seen, but it can be observed by gravity. The ordinary (baryonic) matter is one of the seven mixed branes at equal mass proportions, so the baryonic mass fraction is 1/7 (0.14). The universal baryonic mass fraction was found to be 0.13 by the observations of primordial deuterium abundance [8]. The calculated value agrees well with the observed value.

For ordinary matter (the mixed 3-brane), there are two sets (main and auxiliary) of the seven dimensional orbitals. The total number of dimensional orbitals is 14 as shown in Fig. 4.

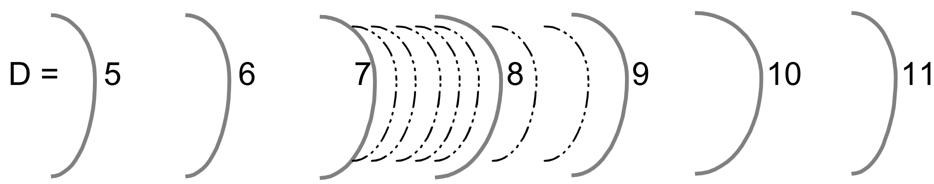



**Fig. 4:** 14 dimensional orbitals in the mixed 3-brane: 7 main dimensional orbitals (solid line), and 7 auxiliary dimensional orbitals (dot line), D = main dimensional orbital number

As shown in Fig. 4, the auxiliary dimensional orbitals are in the middle of the main dimensional orbitals. The fifth main dimensional orbital is the start of the main dimensional orbitals. To be adjacent to the start of the auxiliary dimensional orbitals, the seventh main dimensional orbitals mixes with the fifth orbitals. Such mixing is manifested by the symmetry mixing in the electroweak interaction between U (1) for the fifth main dimensional orbital and SU (2) for the seventh main dimensional orbitals.

Other than gravity (the eleventh main dimensional orbital that relates to mass and energy only), each dimensional orbital carries certain discrete functions as the manifestation of the cosmic evolution. The main dimensional orbitals are for all major functions, and the auxiliary dimensional orbitals are for mostly quarks. Each main dimensional orbital except gravity is assigned to carry gauge symmetry and space-time symmetry.

The fifth main dimensional orbital with U(1) gauge symmetry carries the quantized charge for the two symmetrical internal boundary branes within a mixed brane. During the annihilation in the big bang mode of the vacuum dilution process, the two symmetrical internal boundary branes become massless energy, so the fifth main dimensional orbital is a massless orbital. All other dimensional orbitals except gravity are short-range massive dimensional orbitals. Only the mixed 3-brane (ordinary matter) has the fifth main dimensional orbital, so without the fifth main dimensional orbital, exotic dark matter consists of permanently neutral higher dimensional particles. It cannot emit light, and cannot form atoms.

The sixth main dimensional orbital carries the charge for the asymmetrical internal boundary branes within a mixed brane. The dependence of the auxiliary dimensional orbitals (quarks) on the main dimensional orbitals (leptons) is represented by the colors as in color SU(3) to become colorless as in U(1), so a quark composite must have integer charge and hypercharge, like leptons, in order to have an independent existence.

The seventh main dimensional orbital carries the charge for the gauge symmetry within the family of leptons or quarks. The charge is represented by SU(2) for the symmetry between two leptons (e and ν) or between two quarks (u and d). The same set of gauge symmetry groups is assigned to the eighth, the ninth, and the tenth main dimensional orbitals as U(1), U(1), and SU(2), respectively.

Various space-time symmetries reflect the existence of fermions. P nonconservation is required to achieve chiral symmetry for massless leptons (neutrinos), so masses of higher neutrinos in the lepton family are not too large to fit in the lepton family. In order to have a long-term existence of fermions, CP nonconservation is required to distinguish matter from anti-matter. P and CP nonconservations are in pairs of the right and the left. The seventh, the eighth, the ninth, and the tenth main dimensional orbitals are assigned to have P (left), CP (right), CP (left), and P (right) nonconservation, respectively. There is no nonconservation for the fifth and the sixth main dimensional orbitals.

The combination of the gauge symmetry and the space-time symmetry for the main dimensional orbitals from 5 to 10 results in U(1), SU(3) to become U(1), $SU(2)_L$, $U(1)_R$, $U(1)_L$, and $SU(2)_R$, respectively. The eleventh main dimensional orbital is for gravity in the massless form.

As in Fig. 1, the symmetry between the pre-expanding universe and the mixed pre-expanding universe becomes the pattern for the symmetry between the electric and the magnetic fields. The lack of perfect symmetry between electric and magnetic fields is a reflection of the lack of perfect symmetry between the boundary 9-branes and the boundary mixed 9-branes. The two boundary 9-branes represent two electric charges. The collapse (moving) of the boundary 9-branes generates the two boundary mixed 9-branes, representing two magnetic charges. The observable universe inherits only one boundary mixed 9-brane, which has to assume the role of two magnetic charges at the same time. Therefore, there are separable electric charges, but no separable magnetic charges.

The structure of the mixed 3-brane with dimensional orbitals resembles to the structure of atomic orbital. Consequently, the periodic table of elementary particles is constructed to account of all leptons, quarks, gauge bosons, and hadrons as described in details in Reference 6. It is briefly reviewed here.

For the gauge bosons, the seven main dimensional orbitals are arranged as $F_5$ $B_5$ $F_6$ $B_6$ $F_7$ $B_7$ $F_8$ $B_8$ $F_9$ $B_9$ $F_{10}$ $B_{10}$ $F_{11}$ $B_{11}$, where B and F are boson and fermion in each orbital. The masses of the main dimensional orbital bosons can be derived from Eqs. (2) and (3). Assuming $\alpha_{D,B} = \alpha_{D,F}$ , the relation between the bosons in the adjacent main dimensional orbitals, then, can be expressed in terms of the main dimensional orbital number, D,

$$M_{D-1,\,B} = M_{D,\,B}\ \alpha^2{}_D\ , \qquad (4)$$

where D= 6 to 11, and $E_{5,B}$ and $E_{11,B}$ are the energies for the main dimensional orbital five and the main dimensional orbital eleven, respectively. The lowest energy is the Coulombic field, $E_{5,B}= \alpha\ M_{6,F} = \alpha\ M_e$,

The bosons generated are the main dimensional orbital bosons or $B_D$. Using only $\alpha_e$, the mass of electron, the mass of $Z^0$, and the number (seven) of dimensional orbitals, the masses of $B_D$ as the gauge boson can be calculated as shown in Table 1.

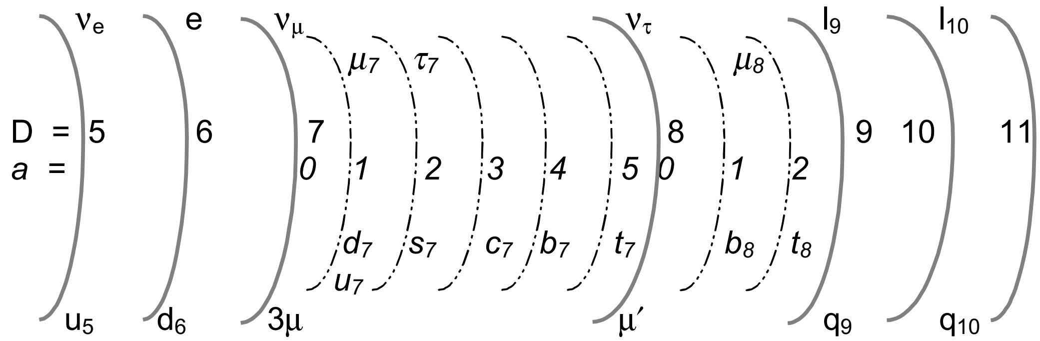
**Table 1.** The Masses of the main dimensional orbital bosons:
$\alpha = \alpha_e$, D = main dimensional orbital number

| $B_D$ | $M_D$ | GeV (calculated) | gauge boson | Interaction, symmetry |
|---|---|---|---|---|
| $B_5$ | $M_e\ \alpha$ | $3.7\text{x}10^{-6}$ (given) | A | electromagnetic, U(1) |
| $B_6$ | $M_e/\alpha$ | $7\text{x}10^{-2}$ | $\pi_{1/2}$ | strong, SU(3) $\longrightarrow$ U(1) |
| $B_7$ | $M_6/\alpha_w^2 \cos\theta_w$ | 91.177 (given) | $Z_L^0$ | weak (left), $SU(2)_L$ |
| $B_8$ | $M_7/\alpha^2$ | $1.7\text{x}10^6$ | $X_R$ | CP (right) nonconservation, $U(1)_R$ |
| $B_9$ | $M_8/\alpha^2$ | $3.2\text{x}10^{10}$ | $X_L$ | CP (left) nonconservation, $U(1)_L$ |
| $B_{10}$ | $M_9/\alpha^2$ | $6.0\text{x}10^{14}$ | $Z_R^0$ | weak (right), $SU(2)_R$ |
| $B_{11}$ | $M_{10}/\alpha^2$ | $1.1\text{x}10^{19}$ | G | gravity |

In Table 1, $\alpha = \alpha_e$ (the fine structure constant for electromagnetic field), and $\alpha_w$ is not same as $\alpha$ of the rest, because there is a mixing between $B_5$ and $B_7$ as the symmetry mixing between U(1) and SU(2) in the standard theory of the electroweak interaction, and $\sin\theta_w$ is not equal to 1. As shown in Reference 6, $B_5$, $B_6$, $B_7$, $B_8$, $B_9$, and $B_{10}$ are A (massless photon), $\pi_{1/2}$, $Z_L^0$, $X_R$, $X_L$, and $Z_R^0$, respectively, responsible for the electromagnetic field, the strong interaction, the weak (left handed) interaction, the CP (right handed) nonconservation, the CP (left handed) nonconservation, and the P (right handed) nonconservation, respectively. The calculated value for $\theta_w$ is $29.69^0$ in good agreement with $28.7^0$ for the observed value of $\theta_w$ [9]. The calculated energy for $B_{11}$ is $1.1\text{x}10^{19}$ GeV in good agreement with the Planck mass, $1.2\text{x}10^{19}$ GeV.

The two sets of seven dimensional orbitals result in 14 dimensional orbitals (Fig. 5) for gauge bosons, leptons, and quarks. The periodic table for elementary particles is shown in Table 2.

Lepton mixed 3-brane




Quark mixed 3-brane

**Fig. 5.** leptons and quarks in the dimensional orbits
D = main dimensional number, a = auxiliary dimensional number

**Table 2.** The Periodic Table of elementary particles
D = main dimensional orbital number, a = auxiliary dimensional orbital number

| D | a = 0 | 1 | 2 | a = 0 | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Lepton | | | Quark | | | | | | Boson |
| 5 | $l_5 = \nu_e$ | | | $q_5 = u_5 = 3\nu_e$ | | | | | | $B_5 = A$ |
| 6 | $l_6 = e$ | | | $q_6 = d_6 = 3e$ | | | | | | $B_6 = \pi_{1/2}$ |
| 7 | $l_7 = \nu_\mu$ | $\mu_7$ | $\tau_7$ | $q_7 = 3\mu$ | $u_7/d_7$ | $s_7$ | $c_7$ | $b_7$ | $t_7$ | $B_7 = Z_L^0$ |
| 8 | $l_8 = \nu_\tau$ | $\mu_8$ | | $q_8 = \mu'$ | $b_8$ | $t_8$ | | | | $B_8 = X_R$ |
| 9 | $l_9$ | | | $q_9$ | | | | | | $B_9 = X_L$ |
| 10 | $F_{10}$ | | | | | | | | | $B_{10} = Z_R^0$ |
| 11 | $F_{11}$ | | | | | | | | | $B_{11} = G$ |

D is the dimensional orbital number for the seven main dimensional orbitals. The auxiliary dimensional orbital number, a, is for the seven auxiliary dimensional orbitals, mostly for subquarks. All gauge bosons, leptons, and subquarks are located on the seven dimensional orbitals and seven auxiliary dimensional orbitals. Quarks and heavy leptons (μ and τ) are in seven auxiliary spatial dimensions. Most leptons are dimensional orbital fermions, while all quarks are the sums of subquarks.

The fermion mass formula for massive leptons and quarks is derived from Reference 6 as follows.

$$
\begin{aligned}
M_{F_{D,a}} &= \sum M_{F_{D,0}} + M_{AF_{D,a}} \\
&= \sum M_{F_{D,0}} + \frac{3}{2} M_{B_{D-1,0}} \sum_{a=0}^{a} a^4 \\
&= \sum M_{F_{D,0}} + \frac{3}{2} M_{F_{D,0}} \alpha_D \sum_{a=0}^{a} a^4
\end{aligned}
\qquad (5)
$$

Each fermion can be defined by dimensional orbital numbers (D's) and auxiliary dimensional orbital numbers (a's). The compositions and calculated masses of leptons and quarks are listed in Table 3.

**Table 3.** The Compositions and the Constituent Masses of Leptons and Quarks
D = main dimensional orbital number and a = auxiliary dimensional orbital number

| | $D_a$ | Composition | Calc. Mass |
|---|---|---|---|
| Leptons | $D_a$ for leptons | | |
| $\nu_e$ | $5_0$ | $\nu_e$ | 0 |
| E | $6_0$ | e | 0.51 MeV (given) |
| $\nu_\mu$ | $7_0$ | $\nu_\mu$ | 0 |
| $\nu_\tau$ | $8_0$ | $\nu_\tau$ | 0 |
| $\mu$ | $6_0 + 7_0 + 7_1$ | $e + \nu_\mu + \mu_7$ | 105.6 MeV |
| $\tau$ | $6_0 + 7_0 + 7_2$ | $e + \nu_\mu + \tau_7$ | 1786 MeV |
| Quarks | $D_a$ for quarks | | |
| U | $5_0 + 7_0 + 7_1$ | $u_5 + q_7 + u_7$ | 330.8 MeV |
| D | $6_0 + 7_0 + 7_1$ | $d_6 + q_7 + d_7$ | 332.3 MeV |
| S | $6_0 + 7_0 + 7_2$ | $d_6 + q_7 + s_7$ | 558 MeV |
| C | $5_0 + 7_0 + 7_3$ | $u_5 + q_7 + c_7$ | 1701 MeV |
| B | $6_0 + 7_0 + 7_4$ | $d_6 + q_7 + b_7$ | 5318 MeV |
| T | $5_0 + 7_0 + 7_5 + 8_0 + 8_2$ | $u_5 + q_7 + t_7 + q_8 + t_8$ | 176.5 GeV |

There are only three generations of leptons and quarks, because according to calculation, only three generations of quarks can fit in exactly seven auxiliary dimensional orbitals. The calculated masses are in good agreement with the observed constituent masses of leptons and quarks [10,11]. The mass of the top quark found by Collider Detector Facility is 176 ± 13 GeV [10] in a good agreement with the calculated value, 176.5 GeV.

As shown in Reference 6, the masses of hadrons can also be calculated based on binding energy derived from the auxiliary dimensional orbitals. The calculated values for the masses of hadrons are in good agreement with the observed values.

The masses of leptons, quarks, gauge bosons, and hadrons are calculated with only four known constants: the number of spatial dimensions, the mass of electron, the mass of Z°, and $\alpha_e$. Most importantly, the calculation shows that exactly seven main and seven auxiliary dimensional orbitals are needed for all fundamental interactions, leptons, quarks, and hadrons.

## 6. *The Cyclic Universe*

The hidden universe and the observable universe are parallel to each other. The hidden universe is hidden from the observable universe until the quintessence transition [12], when the hidden universe fractionalizes into mixed 3-brane, compatible with the empty mixed 3-brane in the observable universe. The empty mixed 3-brane provides the place for the gravity in the hidden universe to be a massless force field as the gravity in the observable universe. It is manifested as the fifth dimension space for massless anti-gravity as in the Randall - Sundrum mechanism [13] as Fig.6.

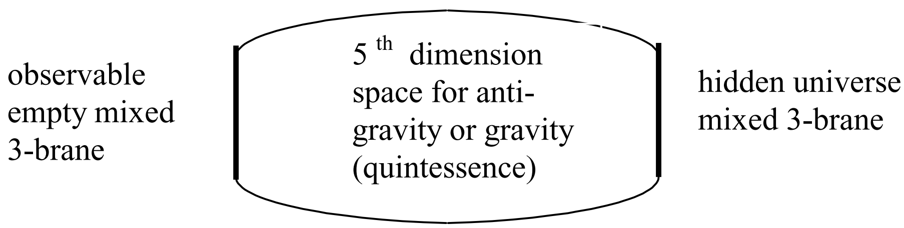



**Fig. 6:** Quintessence

It is anti-gravity because the franctionalization of the hidden universe is expansion. This anti-gravity is massless quintessence, causing the late cosmic accelerating expansion in the observable universe.

After a certain period, the hidden universe starts the condensation (contraction) phase. The hidden universe mixed 3-brane starts to condense into mixed 4-brane, inducing gravity in the fifth dimension space. Consequently, quintessence in the observable universe causes the cosmic contraction. When all hidden universe mixed 3-branes are converted into mixed 4-branes, the quintessence ceases to exist.

The quintessence transition involves both the accelerating expansion and the contraction for the observable universe. Quintessence controls the rate of expansion and contraction for the observable universe during the quintessence period. It makes the hidden and the observable universes to have the same size and to contract at the same rate, so eventually both the observable universe and the hidden universe end at the same time.

At the end of the contraction, the hidden universe becomes the hidden mixed 9-brane, and the observable universe becomes a cosmic black hole without the empty space. With extremely small space and without the empty space, the cosmic black hole is converted back into the observable boundary mixed 9-brane as in the beginning of the mixed pre-expanding universe. At the end of the contraction, the universe again becomes the mixed pre-expanding universe with the boundary 9-mixed branes with the pre-gravity. This mixed pre-expanding universe then starts another cycle of the universe.

## 7. Conclusion

The origin of physical laws comes from the cosmic evolution of vacuum in four stages: the pre-universe vacuum, the void space, the adjacent vacuum, and the empty space. The pre-universe is a vacuum with the vacuum energy slightly below the Planck energy. The vacuum fluctuation of the pre-universe vacuum results in pairs of supermembrane and anti-supermembrane and the void space. The supermembrane pairs and the void space are self-arranged into the semi-stable pre-expanding universe consisting of the positive and the negative energy boundary 9-branes separated by the bulk space with the positive energy pre-gravity and the negative energy pre-gravity. The collapse and the bounce of the pre-expanding universe result in the mixed pre-expanding universe consisting of the boundary mixed 9-branes with the absorbed void space. When the absorbed void space is emitted, it becomes the adjacent vacuum as the added space to bring about the expansion with zero vacuum energy. The expansion is in the form of the big bang mode for the observable universe and in the form of the big band mode for the hidden universe. In the observable universe after the superluminal inflation, the empty space emerges as the gap among the mixed branes. The emergence of the empty space brings about the big bang, cosmic radiation, observable elementary particles, all force fields, and quantum mechanics. The periodic table of elementary particles is constructed to account for all elementary particles and their masses in a good agreement with the observed values.

In the hidden universe, there is no empty space, and the hidden universe expands and contracts slowly like a big rubber band. The interaction between the observable universe and the hidden universe brings about the quintessence that allows the observable universe and the hidden universe to have the same size and contract at the same rate. Eventually, the observable universe and the hidden universe form the mixed pre-expanding universe, which starts another cycle of the universe as Fig. 7.

***the pre-universe***

↓ *the pre-universe vacuum fluctuation*

***the pre-expanding universe***

↓ *the absorption of the void space*

***the mixed pre-expanding universe***

*the adjacent vacuum and the empty space* ↙ ↖ *the loss of the adjacent vacuum and the empty space*

***the expansion*** ***the contraction***

*the compatibility* ↘ ***the quintessence*** ↗ *the incompatibility*

**Fig. 7**: cyclic universe

## References

[1] E. P. Tryon, Nature **246** (1973) 396; A. H. Guth, "The Expanding Universe" (Addison-Wesley Publishing Company, Inc. New York, 1997), Chapter 1; D. Chung, hep-th/0112036.
[2] P. Horava and E. Witten, Nucl. Phys. **B475** (1996) 94 [hep-th/9603142].
[3] J. Khoury, B. A. Ovrut, P. J. Steinhardt, and N. Turok, hep-th/0103239; R. Kallosh, L. Kofman, and A. Linde, hep-th/0104073; S. Rasanen, hep-th/0111279.
[4] C. P. Burgess, M. Majumdar, D. Nolte, F. Quevedo, G. Rajesh, and R. J. Zhang, hep-th/0105204; G. Shiu and S. H. H. Tye, hep-th/0106274; M. Bucher, hep-th/0107148; A. Nornov, hep-th/0109090; M.F. Parry, D. A. Steer, hep-th/0109207, D. Langlois, K. Maeda, D. Wards, gr-qc/0111013; J. Garriga, T. Tanaka, hep-th/0112028.
[5] J. Khoury, B. A. Ovrut, N. Seiberg, P. J. Steinhardt, and N. Turok, hep-th/0108187; P. J. Steinhardt, and N. Turok, hep-th/0111098; P. J. Steinhardt, and N. Turok, astro-ph/0112537; J. Martin, P. Peter, N. Pinto-Neto, and D. Schwarz, hep-th/0112128.
[6] D. Chung, hep-ph/0003237.
[7] A. Linde, Phys. Rev D**49** (1994) 748 [hep-ph/9307002], G. Felder, J. Garcia-Bellido, P. B. Greene, L. Kofman, A. Linde, I. Tkachev, Phys. Rev. Lett. **87** (2001) 011601 [hep-ph/0012142]; C. Herdeiro, S. Hirano, and R. Kallosh, hep-th/0111147.
[8] D. Tytler, S. Burles, L. Lu, X-M, Fan, A. Wolfe, and B. Savage, AJ, **117** (1999) 63; F. C. van den Bosch, A. Burkert, and R. A. Swaters, astro-ph/0105082
[9] P. Langacher, M. Luo, and A. Mann, Rev. Mod. Phys. **64** (1992) 87.
[10] CDF Collaboration, 1995 Phys. Rev. Lett **74** (1995) 2626.
[11] C.P. Singh, Phys. Rev. D**24** (1981) 2481; D. B. Lichtenberg Phys. Rev. D**40** (1989) 3675.
[12] N. Balcall, J.P. Ostriker, S. Perlmutter, and P.J. Steinhardt, Science **284**, 1481-1488, (1999); C. Armedariz-Picon, V. Mukhanov, and P.J. Steinhardt, Phys.Rev.Lett. **85**, 4438 (2000).
[13] L. Randall and R. Sundrum, Nucl. Phys. **B557** (1999) 79; Phys. Rev. Lett. **83** (1999)